CLAIMS

We claim:

1. A method of performing a calculation with a quantum computer, comprising:

providing a plurality of qubit devices including a first qubit device and a second qubit device, each of said plurality of qubit devices including a superconducting loop and one or more superconducting fingers, said superconducting loop including at least one Josephson junction, each of said one or more superconducting fingers extending from said superconducting loop towards the interior of said superconducting loop, each of said one or more superconducting fingers further including a mesoscopic island separated from the rest of said superconducting finger by a finger Josephson junction;

initializing each of said qubits, including initializing a first qubit and a second qubit;

performing a calculation, including performing an entanglement operation on said first qubit and said second qubit; and

reading out the result of the calculation, including measuring a first qubit value and a second qubit value.

2. The method of claim 1, wherein performing an entanglement operation comprises coherently coupling said first qubit device to said second qubit device.

3. The method of claim 1, wherein performing a calculation further comprises performing a bias operation on said first qubit.

4. The method of claim 1, wherein performing a calculation further comprises performing a tunnel matrix operation on said first qubit.

5. The method of claim 1, wherein performing an entanglement operation further comprises performing a controlled phase shift on said first qubit.

6. The method of claim 1, further comprising storing the results of said calculation in a memory, including storing said first qubit value in said memory.

7. The method of claim 1, wherein said first qubit device includes a first superconducting loop and a first mesoscopic island, and wherein measuring said first qubit value includes providing a link between said first superconducting loop and said

first mesoscopic island, providing current through said first qubit device, and measuring a voltage across said first qubit device.

8. The method of claim 1, wherein measuring said first qubit value includes providing current through said first qubit device, and measuring a voltage across said first qubit device.

9. The method of claim 1, wherein said first qubit device includes a first mesoscopic island, and wherein measuring said first qubit value includes grounding said first mesoscopic island, providing current through said first qubit device, and measuring a voltage across said first qubit device.

10. The method of claim 1, wherein said first qubit device includes a first mesoscopic island and said second qubit device includes a second mesoscopic island and wherein performing an entanglement operation on said first qubit and said second qubit includes providing a link between said first mesoscopic island and said second mesoscopic island..

11. A method of initializing a qubit, the method comprising:

providing a qubit device including a qubit, said qubit having two qubit basis states, said qubit device comprising a material capable of superconducting, said qubit device including a loop and a finger, said loop including at least one Josephson junction, said finger extending from said loop towards the interior of said loop, said finger further including a mesoscopic island separated from the rest of said finger by a finger Josephson junction, said qubit device further including a first lead and a second lead configured to provide current to said loop; and

initializing said qubit to one of said two qubit basis states.

12. The method of claim 11, wherein said qubit includes said finger.

13. The method of claim 11, wherein initializing said qubit includes connecting said mesoscopic island of said finger to a ground.

14. The method of claim 11, wherein initializing said qubit includes connecting said mesoscopic island of said finger to said loop.

15. The method of claim 14 wherein said initializing said qubit further includes driving a bias current across said first and second leads of said loop.

16. The method of claim 11, wherein initializing said qubit includes providing a bias current through said first and second leads.

17. A method for entangling a first qubit with a second qubit, said method comprising:

providing a first qubit device having a first qubit, said first qubit device including a superconducting loop and a superconducting finger, said superconducting loop including at least one Josephson junction, said superconducting finger extending from said superconducting loop towards the interior of said superconducting loop, said superconducting finger further including a first mesoscopic island separated from the rest of said superconducting finger by a finger Josephson junction;

providing a second qubit device having a second qubit, said second qubit device including a superconducting loop and a superconducting finger, said superconducting loop including at least one Josephson junction, said superconducting finger extending from said superconducting loop towards the interior of said superconducting loop, said superconducting finger further including a second mesoscopic island separated from the rest of said superconducting finger by a finger Josephson junction; and

coupling said first qubit to said second qubit.

18. The method of claim 17, wherein coupling said first qubit to said second qubit includes providing a link between said first mesoscopic island and said second mesoscopic island.

19. The method of claim 18, said link between said first mesoscopic island and said second mesoscopic island includes a switch, and wherein coupling said first qubit to said second qubit includes closing said switch so that supercurrent can flow between said first mesoscopic island and said second mesoscopic island.

20. The method of claim 19, wherein said switch includes a superconducting single electron transistor.

21. The method of claim 19, wherein said switch includes a parity key.

22. A method of performing a bias operation on a qubit, said method comprising:

providing a qubit device including a qubit, said qubit device including a superconducting loop and a superconducting finger, said superconducting loop

including at least one Josephson junction, said superconducting finger extending from said superconducting loop towards the interior of said superconducting loop, said superconducting finger further including a mesoscopic island separated from the rest of said superconducting finger by a finger Josephson junction;

linking said mesoscopic island to said superconducting loop, wherein said linking is accomplished using a coherent switching mechanism.

23. The method of claim 22, wherein said coherent switching mechanism includes a parity key device.

24. The method of claim 22, wherein said coherent switching mechanism includes a superconducting single electron transistor device.

25. A method for performing a bias operation on a qubit device, said method comprising:

providing a qubit device including a qubit, said qubit device including a superconducting loop and a superconducting finger, said superconducting loop including at least one Josephson junction, said superconducting finger extending from said superconducting loop towards the interior of said superconducting loop, said superconducting finger further including a mesoscopic island separated from the rest of said superconducting finger by a finger Josephson junction, said qubit device further including a first lead and a second lead configured to provide current to said superconducting loop; and

driving a current across said first and second leads.

26. The method of performing a bias operation of claim 25, wherein driving said current across said first and second leads in a first direction biases said qubit device to a first qubit basis state and wherein driving said current across said first and second leads in a second direction opposite to said first direction biases said qubit device to a second qubit basis state.

27. A method of reading out the state of a qubit, said method comprising:

providing a qubit device including a qubit, where said qubit device includes a superconducting loop having a first lead and a second lead and a superconducting finger extending toward the interior of said loop, said superconducting finger including a mesoscopic island separated from the rest of said finger by a Josephson junction;

coupling said mesoscopic island to said superconducting loop;

driving a bias current through said first and second leads; and

measuring a voltage across said first and second leads.

28. The method of claim 27, wherein said qubit includes said finger.

29. A method of reading out the state of a qubit, said method comprising:

providing a qubit device including a qubit, where said qubit device includes a superconducting loop having a first lead and a second lead and a superconducting finger extending toward the interior of said loop, said superconducting finger including a mesoscopic island separated from the rest of said finger by a Josephson junction;

grounding said qubit;

applying a current across said first and second leads of said qubit device; and

measuring a voltage across said first and second leads of said qubit device.

30. A method of grounding a qubit, said method including:

providing a qubit device including a qubit, where said qubit device includes a superconducting loop and a superconducting finger extending toward the interior of said loop, said superconducting finger including a mesoscopic island separated from the rest of said finger by a Josephson junction; and

connecting said mesoscopic island to a ground.

31. The method of claim 30, wherein said qubit includes said superconducting finger.

32. A method of grounding a qubit, said method including:

providing a qubit device including a qubit, where said qubit device includes a superconducting loop having a first lead and a second lead and a superconducting finger extending toward the interior of said loop, said superconducting finger including a mesoscopic island separated from the rest of said finger by a Josephson junction; and

driving current across said first and second leads.

33. A method for entangling a plurality of qubits, said method including:

providing a plurality of qubit devices, each of said qubit devices including a superconducting loop having one or more superconducting fingers extending toward the interior of said loop, each of said superconducting fingers including a mesoscopic island separated from the rest of said finger by a Josephson junction, wherein each of said superconducting fingers forms a qubit; and

entangling a first qubit with a second qubit.

34. The method of claim 33, further including entangling said first qubit with a third qubit.

35. The method of claim 34, wherein said first qubit is entangled with both said second qubit and said third qubit at a time T.